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King et al.

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(54) **LOCAL SECURITY KEY GENERATION**

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H04L 29/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 9/0866*** (2013.01); *H04L 63/062* (2013.01); *H04L 63/08* (2013.01)

(58) **Field of Classification Search**
CPC H04L 9/00; H04L 9/0866; H04L 63/08; H04L 63/062
USPC 713/2; 380/44
See application file for complete search history.

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Primary Examiner — Jaweed A Abbaszadeh
Assistant Examiner — Terrell Johnson

(57) **ABSTRACT**

A calling device may obtain a first calling security parameter by registering with a network and obtain a second calling security parameter in response to causing an application authentication architecture of the network to verify that that the calling device is authorized to access a network service corresponding to a communication application stored by the calling device. The calling device may communicate the first and second calling security parameters to a called device and receive first and second called security parameters from the called device in response to communicating the first and second calling security parameters. The calling device may generate a security key based on the first calling security parameter, the second calling security parameter, first called security parameter, and the second called security parameter, and use the security key to encrypt or decrypt communication between the calling device and the called device.

22 Claims, 10 Drawing Sheets

100

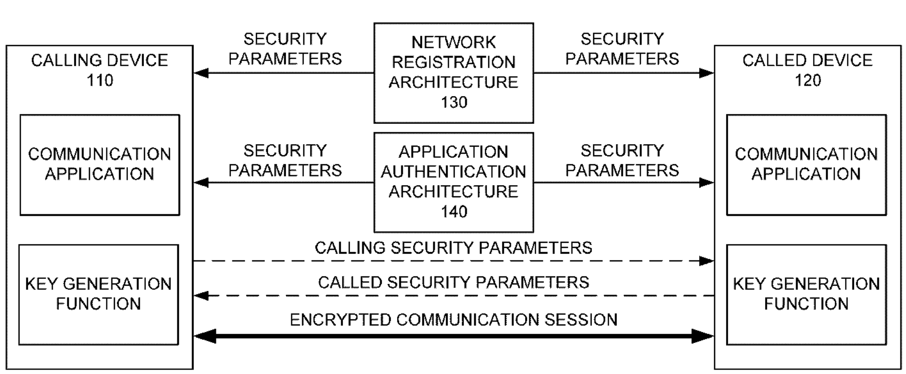

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FIG. 1

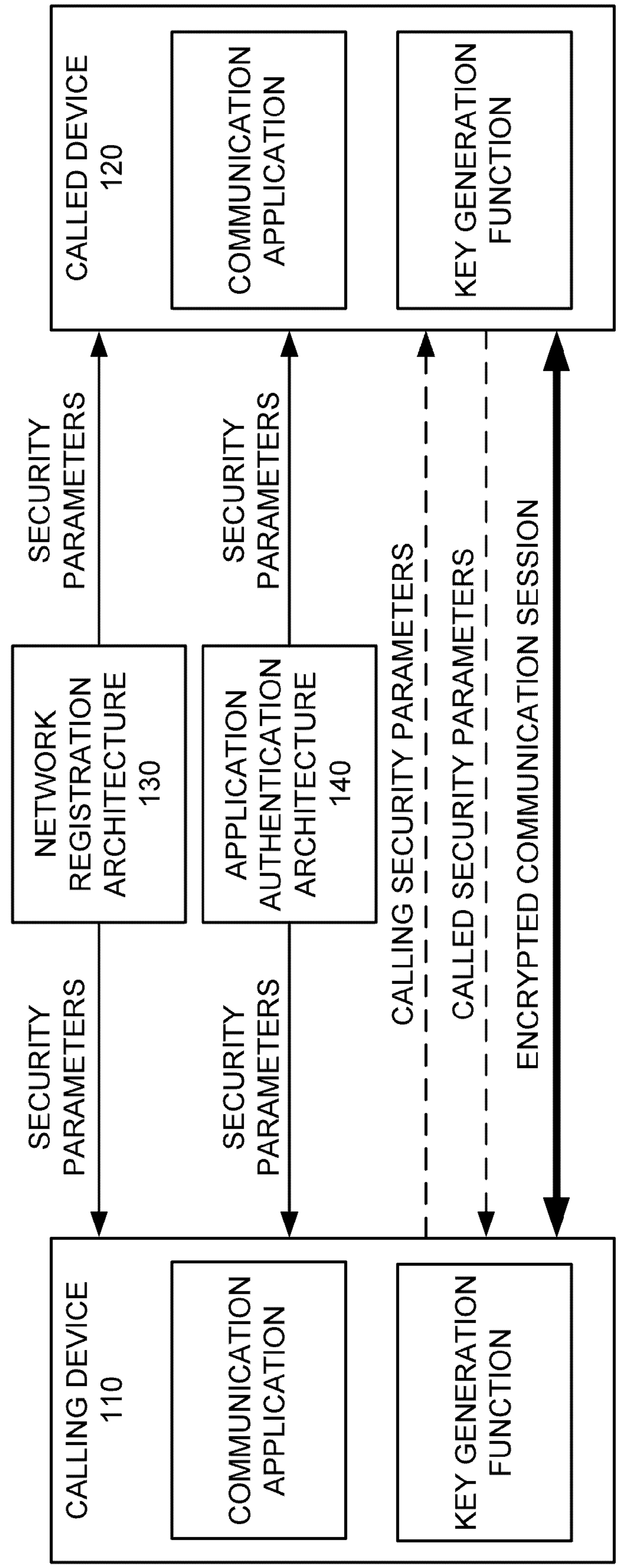

100
CALLING DEVICE 110
COMMUNICATION APPLICATION
KEY GENERATION FUNCTION
CALLED DEVICE 120
COMMUNICATION APPLICATION
KEY GENERATION FUNCTION
NETWORK REGISTRATION ARCHITECTURE 130
APPLICATION AUTHENTICATION ARCHITECTURE 140
SECURITY PARAMETERS
SECURITY PARAMETERS
SECURITY PARAMETERS
SECURITY PARAMETERS
CALLING SECURITY PARAMETERS
CALLED SECURITY PARAMETERS
ENCRYPTED COMMUNICATION SESSION

FIG. 2

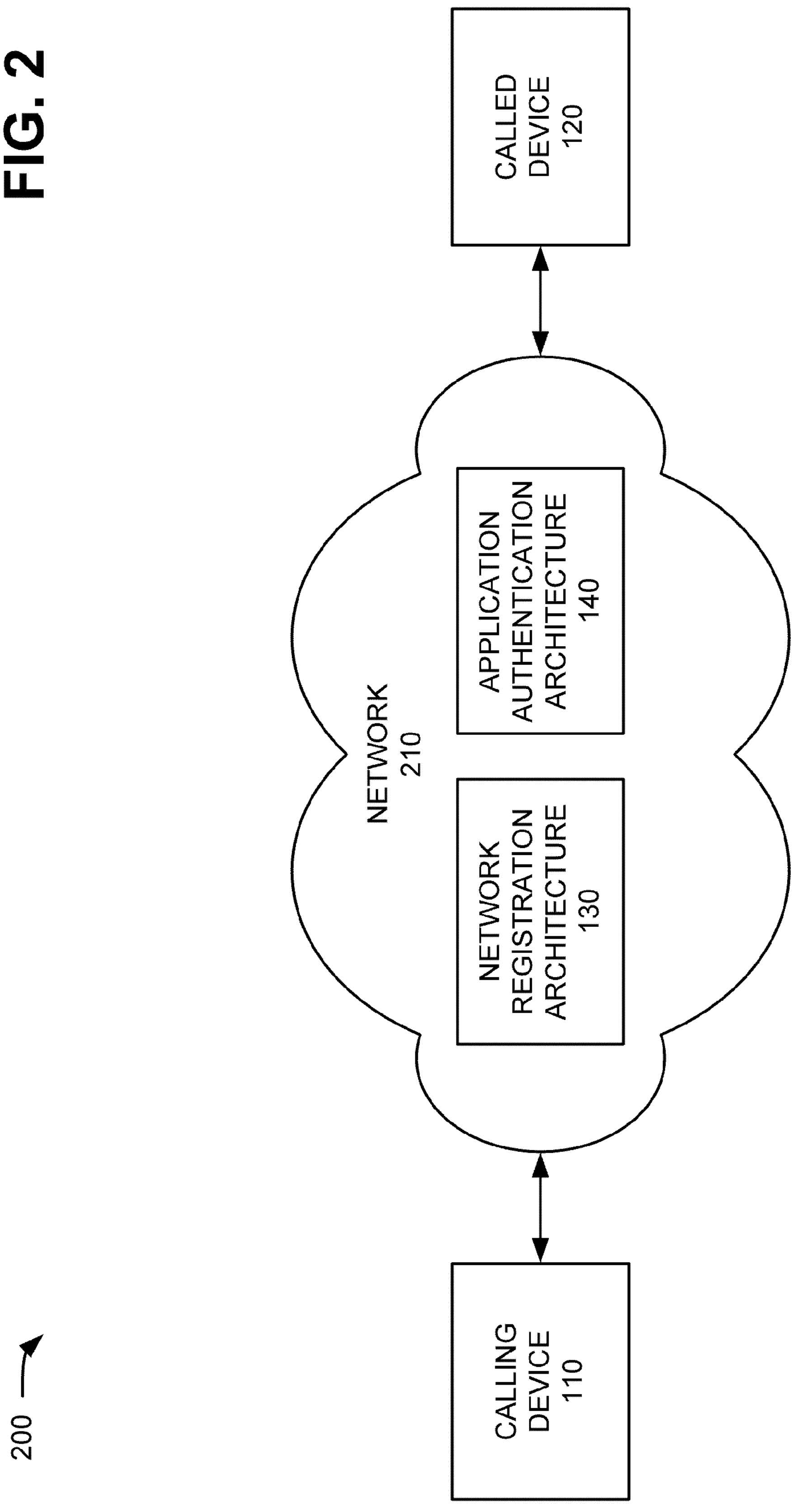

200
CALLED DEVICE 120
NETWORK 210
APPLICATION AUTHENTICATION ARCHITECTURE 140
NETWORK REGISTRATION ARCHITECTURE 130
CALLING DEVICE 110

FIG. 3

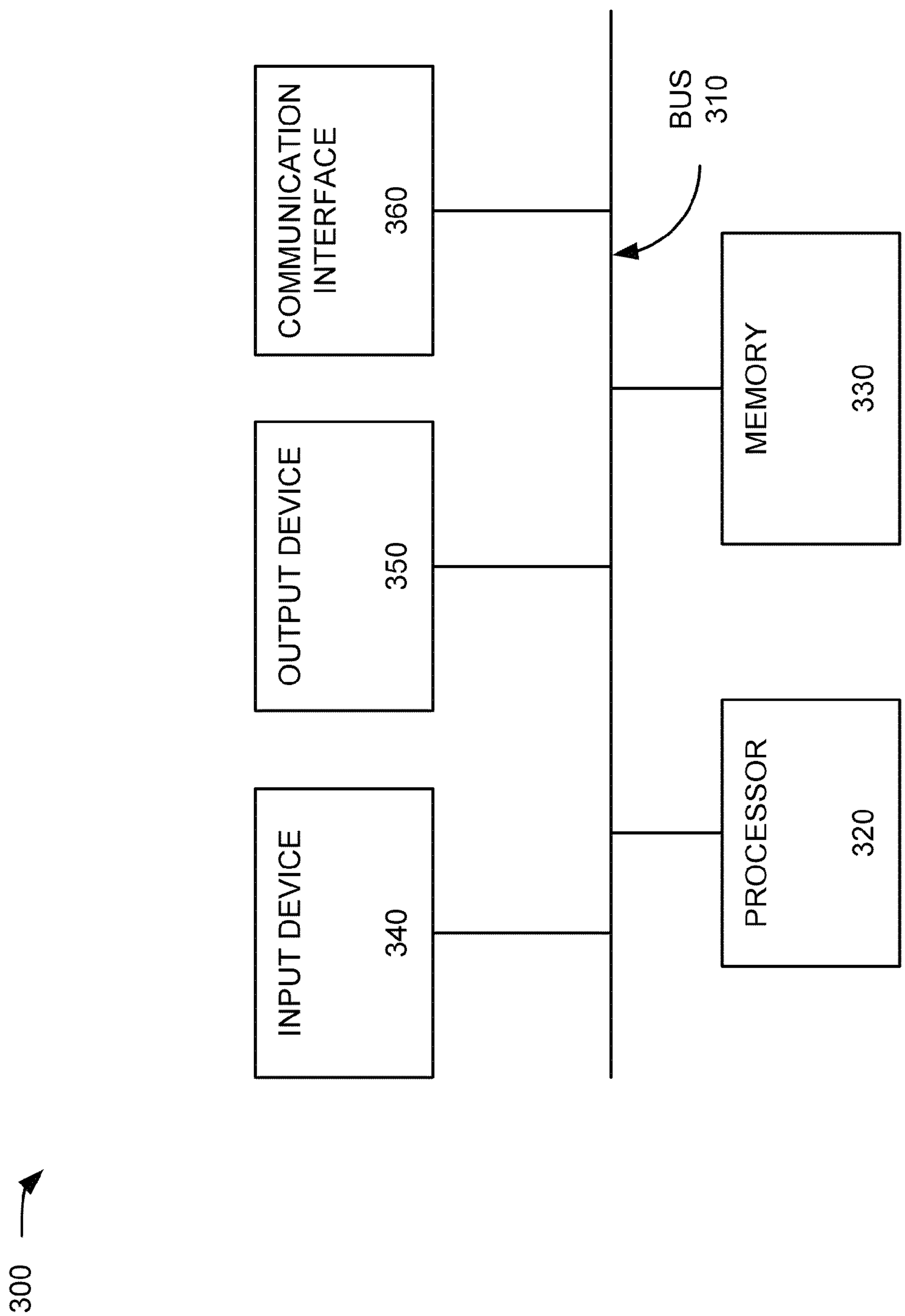

300
INPUT DEVICE 340
OUTPUT DEVICE 350
COMMUNICATION INTERFACE 360
BUS 310
PROCESSOR 320
MEMORY 330

FIG. 4

400

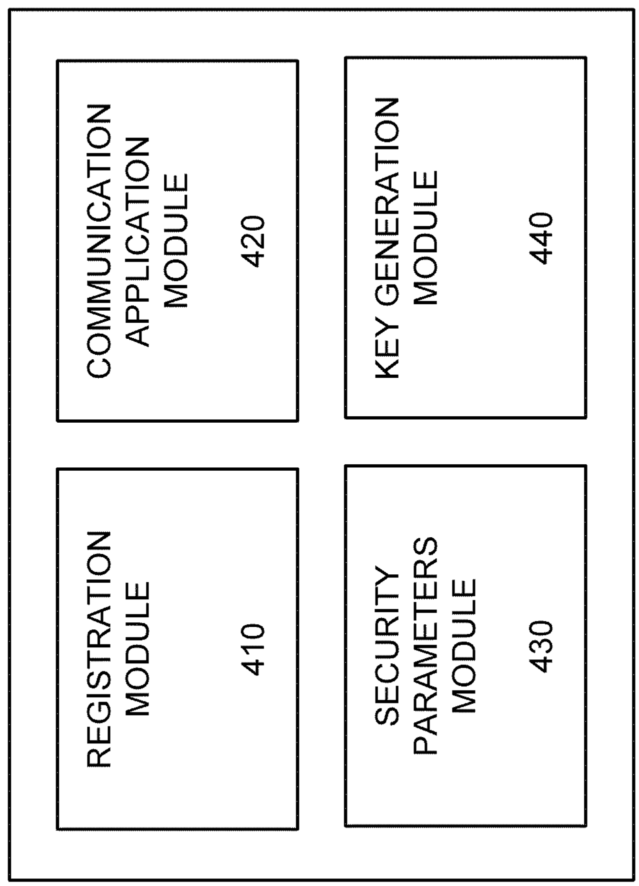
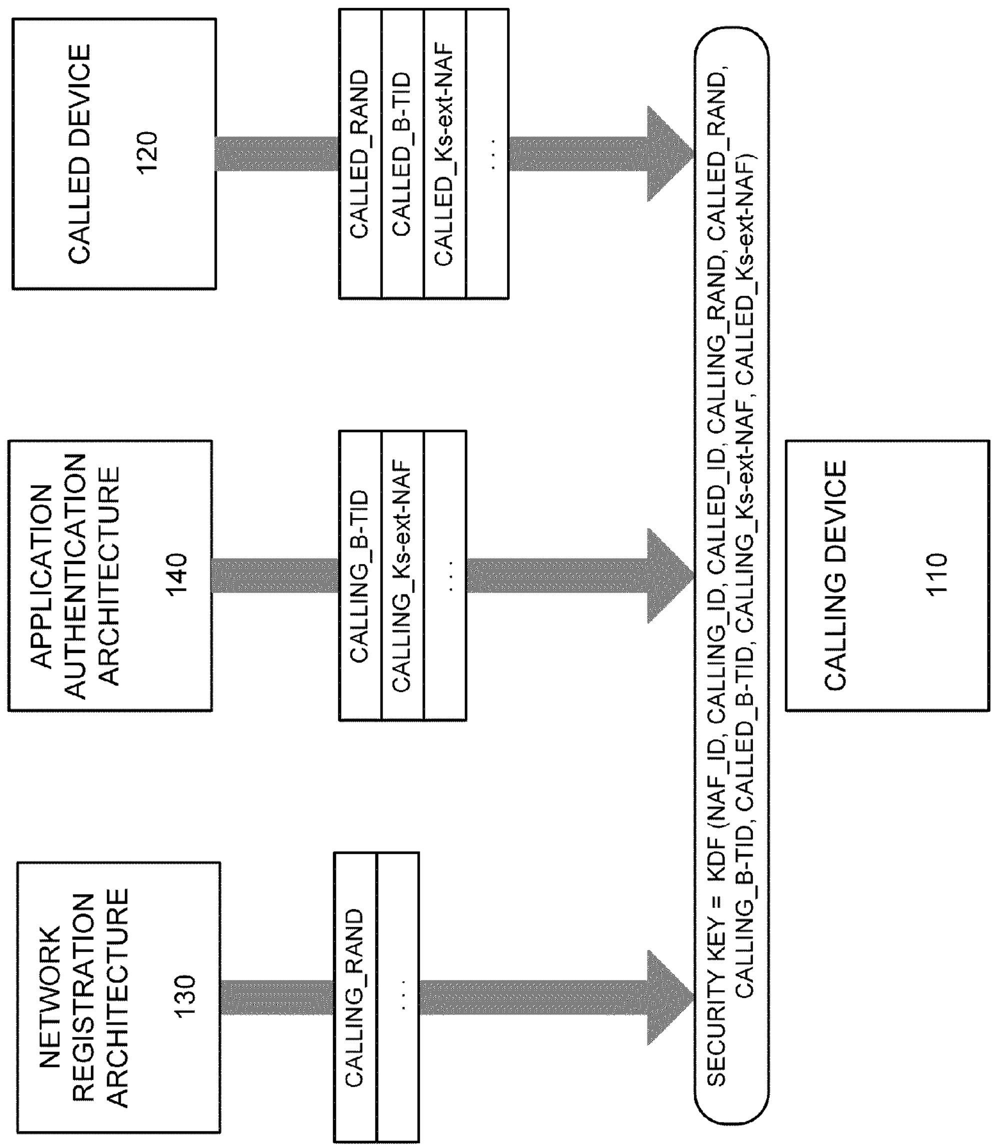

REGISTRATION MODULE
410
COMMUNICATION APPLICATION MODULE
420
SECURITY PARAMETERS MODULE
430
KEY GENERATION MODULE
440

FIG. 5

500


NETWORK REGISTRATION ARCHITECTURE
130
APPLICATION AUTHENTICATION ARCHITECTURE
140
CALLED DEVICE
120
CALLING_RAND
. . .
CALLING_B-TID
CALLING_Ks-ext-NAF
. . .
CALLED_RAND
CALLED_B-TID
CALLED_Ks-ext-NAF
. . .
SECURITY KEY = KDF (NAF_ID, CALLING_ID, CALLED_ID, CALLING_RAND, CALLED_RAND, CALLING_B-TID, CALLED_B-TID, CALLING_B-TID, CALLING_Ks-ext-NAF, CALLED_Ks-ext-NAF)
CALLING DEVICE
110

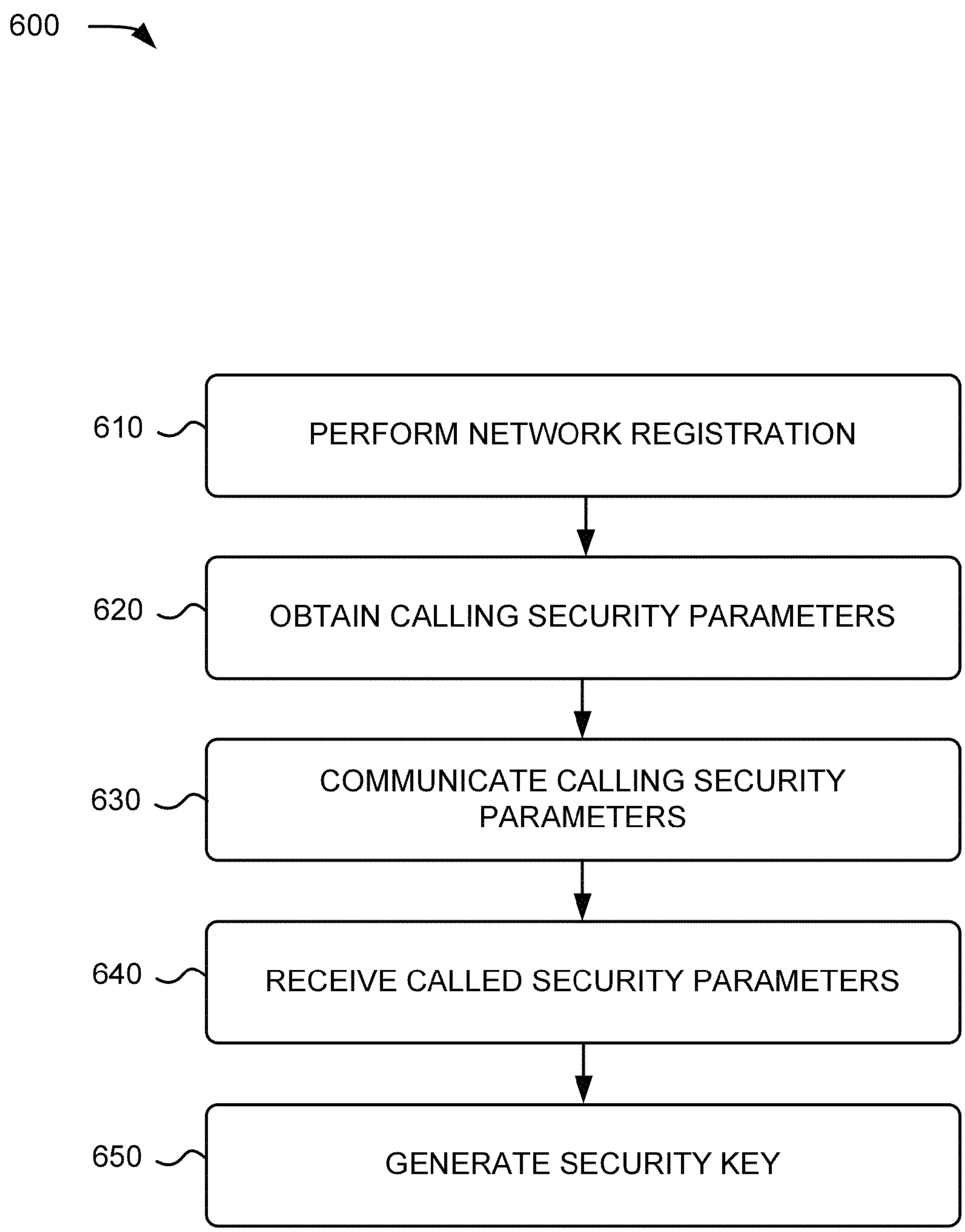

600
610
PERFORM NETWORK REGISTRATION
620
OBTAIN CALLING SECURITY PARAMETERS
630
COMMUNICATE CALLING SECURITY PARAMETERS
640
RECEIVE CALLED SECURITY PARAMETERS
650
GENERATE SECURITY KEY

FIG. 6

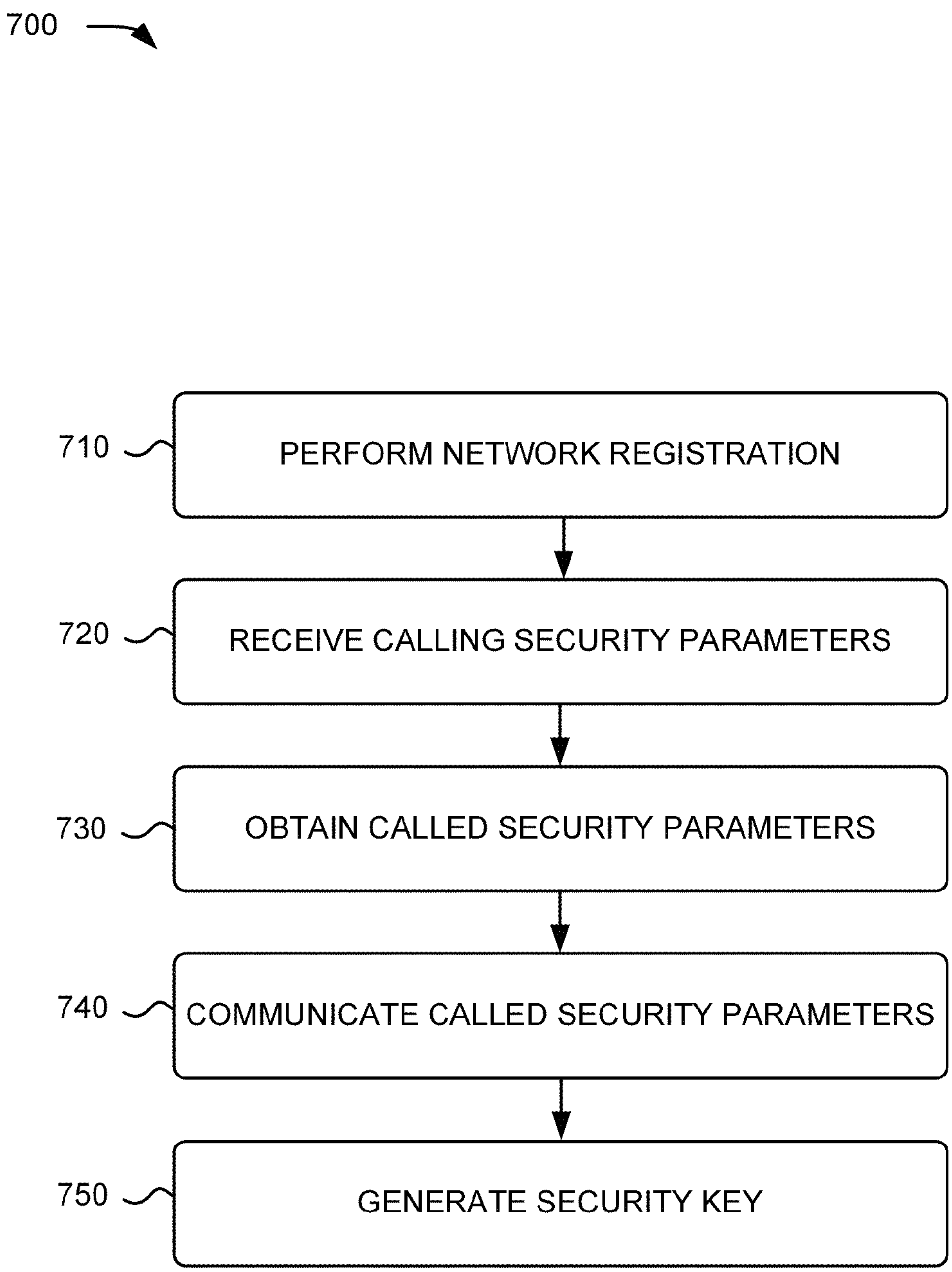

700
710
PERFORM NETWORK REGISTRATION
720
RECEIVE CALLING SECURITY PARAMETERS
730
OBTAIN CALLED SECURITY PARAMETERS
740
COMMUNICATE CALLED SECURITY PARAMETERS
750
GENERATE SECURITY KEY

FIG. 7

FIG. 8A

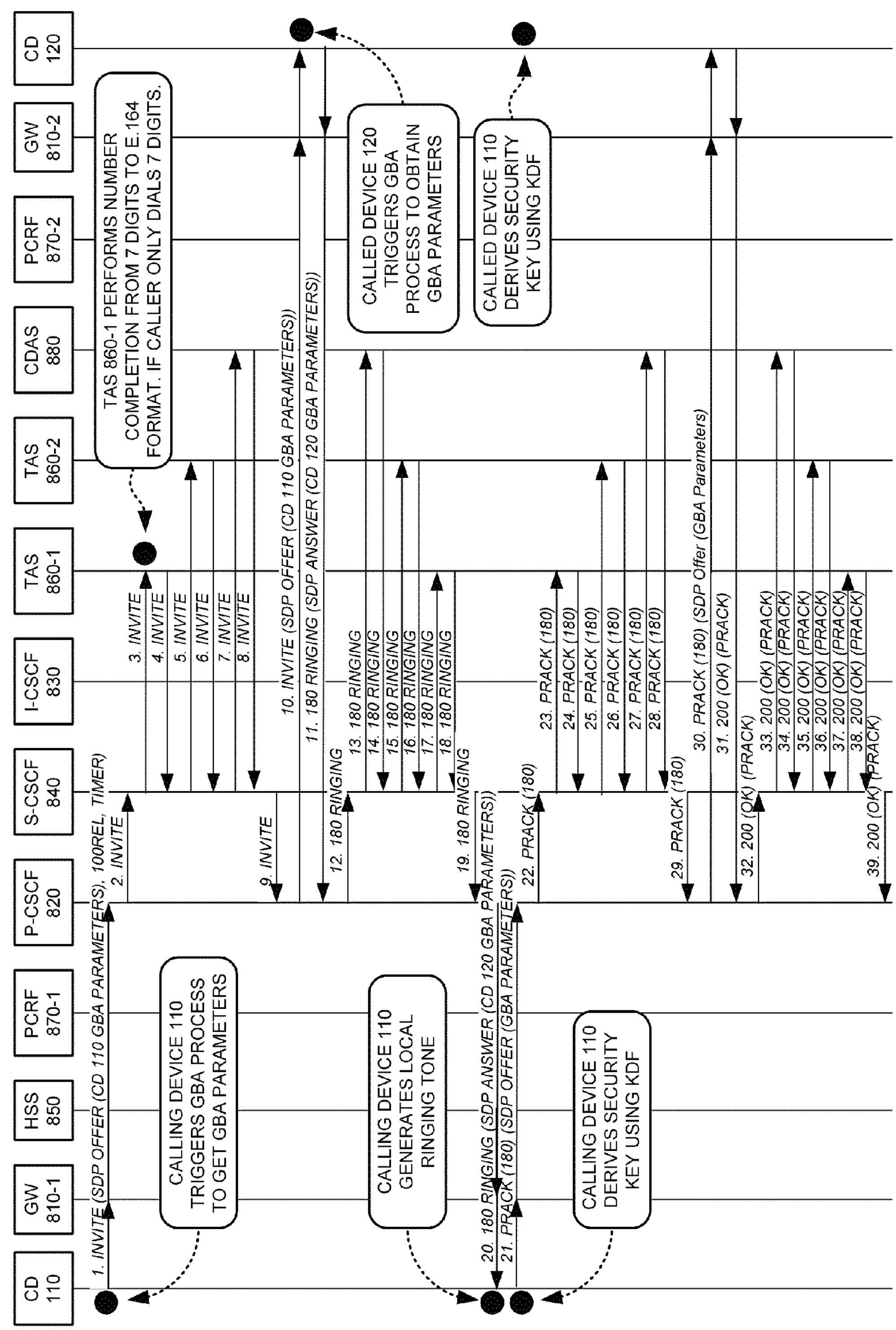
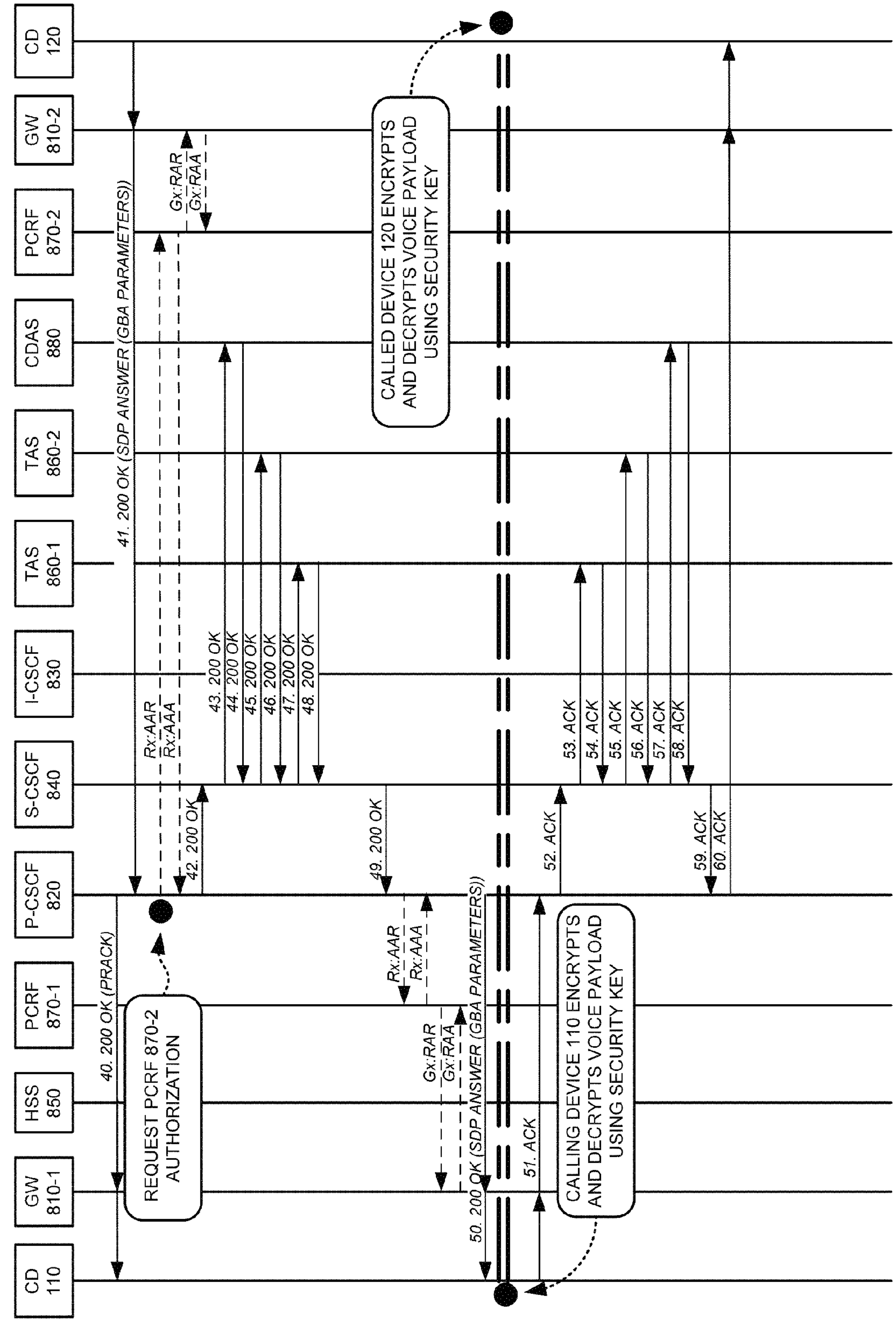

800A
CD 110
GW 810-1
HSS 850
PCRF 870-1
P-CSCF 820
S-CSCF 840
I-CSCF 830
TAS 860-1
TAS 860-2
CDAS 880
PCRF 870-2
GW 810-2
CD 120
CALLING DEVICE 110 TRIGGERS GBA PROCESS TO GET GBA PARAMETERS
CALLING DEVICE 110 GENERATES LOCAL RINGING TONE
CALLING DEVICE 110 DERIVES SECURITY KEY USING KDF
TAS 860-1 PERFORMS NUMBER COMPLETION FROM 7 DIGITS TO E.164 FORMAT. IF CALLER ONLY DIALS 7 DIGITS.
CALLED DEVICE 120 TRIGGERS GBA PROCESS TO OBTAIN GBA PARAMETERS
CALLED DEVICE 110 DERIVES SECURITY KEY USING KDF
1. INVITE (SDP OFFER (CD 110 GBA PARAMETERS), 100REL, TIMER)
2. INVITE
3. INVITE
4. INVITE
5. INVITE
6. INVITE
7. INVITE
8. INVITE
9. INVITE
10. INVITE (SDP OFFER (CD 110 GBA PARAMETERS))
11. 180 RINGING (SDP ANSWER (CD 120 GBA PARAMETERS))
12. 180 RINGING
13. 180 RINGING
14. 180 RINGING
15. 180 RINGING
16. 180 RINGING
17. 180 RINGING
18. 180 RINGING
19. 180 RINGING
20. 180 RINGING (SDP ANSWER (CD 120 GBA PARAMETERS))
21. PRACK (180) (SDP OFFER (GBA PARAMETERS))
22. PRACK (180)
23. PRACK (180)
24. PRACK (180)
25. PRACK (180)
26. PRACK (180)
27. PRACK (180)
28. PRACK (180)
29. PRACK (180)
30. PRACK (180) (SDP Offer (GBA Parameters)
31. 200 (OK) (PRACK)
32. 200 (OK) (PRACK)
33. 200 (OK) (PRACK)
34. 200 (OK) (PRACK)
35. 200 (OK) (PRACK)
36. 200 (OK) (PRACK)
37. 200 (OK) (PRACK)
38. 200 (OK) (PRACK)
39. 200 (OK) (PRACK)

FIG. 8B


800B
CD 110
GW 810-1
HSS 850
PCRF 870-1
P-CSCF 820
S-CSCF 840
I-CSCF 830
TAS 860-1
TAS 860-2
CDAS 880
PCRF 870-2
GW 810-2
CD 120
40. 200 OK (PRACK)
REQUEST PCRF 870-2 AUTHORIZATION
41. 200 OK (SDP ANSWER (GBA PARAMETERS))
Rx:AAR
Rx:AAA
Gx:RAR
Gx:RAA
42. 200 OK
43. 200 OK
44. 200 OK
45. 200 OK
46. 200 OK
47. 200 OK
48. 200 OK
49. 200 OK
Rx:AAR
Rx:AAA
Gx:RAR
Gx:RAA
50. 200 OK (SDP ANSWER (GBA PARAMETERS))
CALLED DEVICE 120 ENCRYPTS AND DECRYPTS VOICE PAYLOAD USING SECURITY KEY
51. ACK
52. ACK
CALLING DEVICE 110 ENCRYPTS AND DECRYPTS VOICE PAYLOAD USING SECURITY KEY
53. ACK
54. ACK
55. ACK
56. ACK
57. ACK
58. ACK
59. ACK
60. ACK

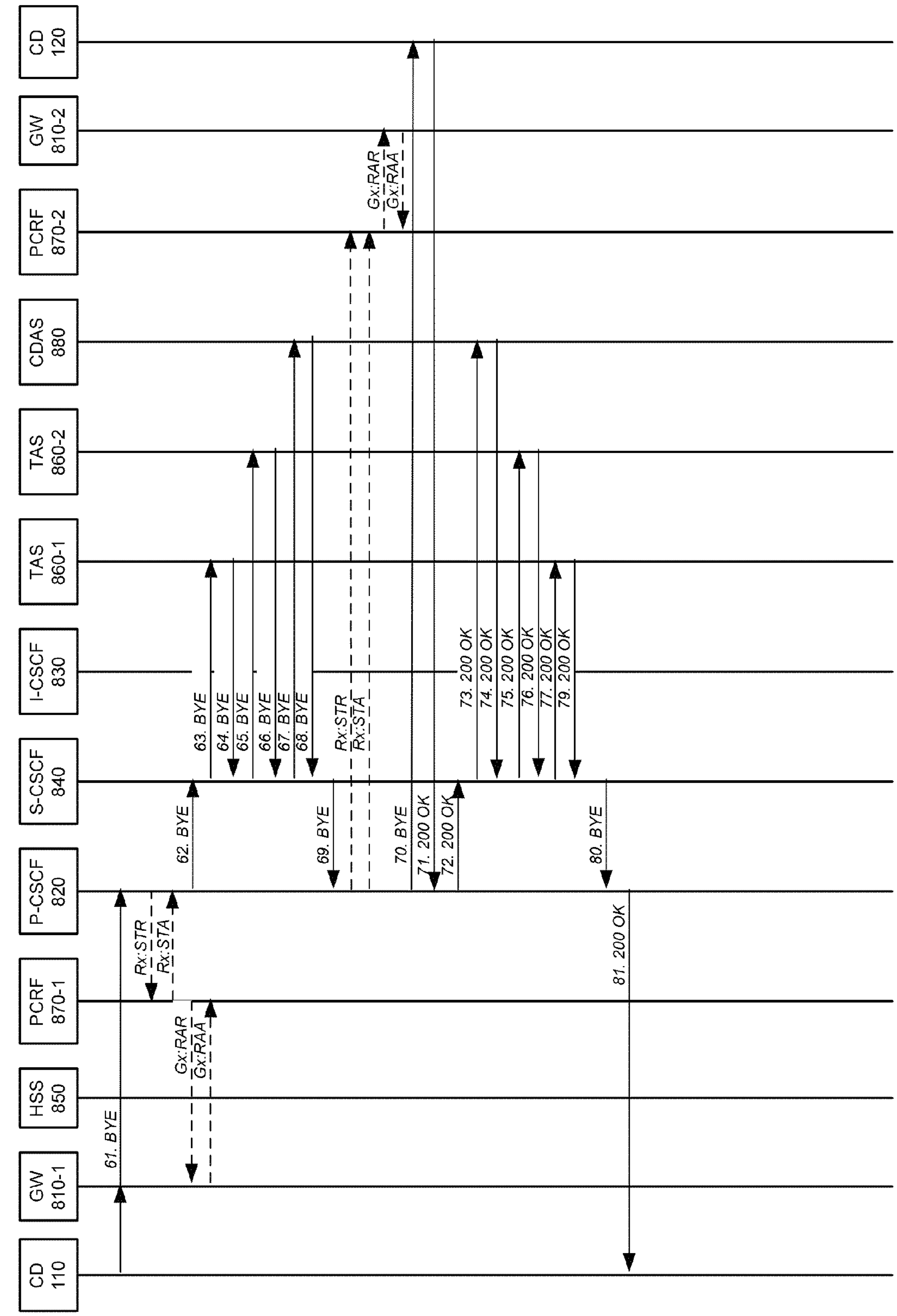

800C
CD 110
GW 810-1
HSS 850
PCRF 870-1
P-CSCF 820
S-CSCF 840
I-CSCF 830
TAS 860-1
TAS 860-2
CDAS 880
PCRF 870-2
GW 810-2
CD 120
61. BYE
Rx:STR
Rx:STA
Gx:RAR
Gx:RAA
62. BYE
63. BYE
64. BYE
65. BYE
66. BYE
67. BYE
68. BYE
69. BYE
Rx:STR
Rx:STA
Gx:RAR
Gx:RAA
70. BYE
71. 200 OK
72. 200 OK
73. 200 OK
74. 200 OK
75. 200 OK
76. 200 OK
77. 200 OK
79. 200 OK
80. BYE
81. 200 OK

FIG. 8C

LOCAL SECURITY KEY GENERATION

BACKGROUND

Current network communication technologies include various approaches to network security. For example, in many networks, user devices are assigned security keys (also referred to as cipher keys) for encrypting and decrypting messages communicated over the network. However, such technologies often include various deficiencies. For instance, assigning security keys to user devices often involves a third device (e.g., a key management system) to assign the security keys, which can introduce security risks and increase operational complexity within the network.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram of an example overview of an implementation described herein;

FIG. **2** is a diagram of an example environment in which systems and/or methods, described herein, may be implemented;

FIG. **3** is a diagram of example components of a device according to one or more implementations described herein;

FIG. **4** is a diagram of example functional components corresponding to one or more implementations described herein;

FIG. **5** is a diagram of an example data flow according to one or more implementations described herein;

FIG. **6** is a diagram of an example process for generating a security key according to one or more implementations described herein;

FIG. **7** is a diagram of another example process for generating a security key according to one or more implementations described herein; and

FIGS. **8**A-**8**C are diagrams of an example call session according to one or more implementations described herein.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same labels and/or reference numbers in different drawings may identify the same or similar elements.

In one or more implementations, described herein, devices may be used to locally generate security keys. For example, a calling device may receive calling security parameters by registering with a network and demonstrating that the calling device is authorized to access a particular network service (e.g., a voice over Internet Protocol (IP) (VoIP) service) and/or use a particular communication application (e.g., a VoIP application). The calling device may communicate the calling security parameters to a called device and, in response, receive called security parameters from the called device. The calling device and the called device may each execute a key generation function based on the calling security parameters and the called security parameters to locally generate security keys for encryption and decryption purposes.

FIG. **1** is a diagram of an example overview **100** of an implementation described herein. As depicted, overview **100** may include calling device **110**, called device **120**, network registration architecture **130**, and application authentication architecture **140**. In some implementations, the systems and devices of FIG. **1** may correspond to one or more systems or device discussed elsewhere in this specification.

Calling device **110** and called device **120** may each include one or more of a variety of devices, such as a telephone, a smart phone, a laptop computer, a tablet computer, a desktop computer, a server, or another type of computing or communication device. For example, calling device **110** and called device **120** may each be a smart phone. However, in another example, calling device **110** may include a tablet computer, and called device **120** may include a network application server. In yet another example, calling device **110** and called device **120** may each be application servers.

Calling device **110** may include a device that sends a communication session invitation (e.g., a call session invitation, a session initiation protocol (SIP) INVITE message, etc.), and called device **120** may include a device that receives the communication session invitation. However, in some implementations, called device **120** may also be capable of sending a communication session invitation, and calling device **110** may be capable of receiving the communication session invitation. In certain implementations, therefore, a particular device (e.g., a smart phone) may operate as calling device **110** in one scenario and called device **120** in another scenario.

As depicted, calling device **110** and called device **120** may include communication applications. The communication applications may enable calling device **110** and called device **120** to communicate with one another via a particular type of network service. For example, a communication application may include a VoIP application, a simple message service (SMS) application, an instant messaging (IM) application, a video conference application, or another type of communication application. In some implementations, before a communication application may be used, application authentication architecture **140** may perform one or more authentication or authorization processes to verify that calling device **110** or called device **120** are authorized to use the communication applications and/or corresponding network service.

Additionally, or alternatively, calling device **110** and called device **120** may include key generation functions. The key generation functions may enable calling device **110** and called device **120** to generate a security key based on one or more security parameters. In certain implementations, the key generation function of the calling device **110** and the key generation function of the called device **120** may be the same. For example, in some implementations, if the same parameters are inputted into the key generation function of the calling device **110** and the key generation function of the called device **120**, the outputs of both key generation functions may be the same.

Network registration architecture **130** may include one or more of a variety of computing devices. For example, network registration architecture **130** may include a desktop computer, a server, a cluster of servers, or one or more other types of computing or communication devices. In some implementations, network registration architecture **130** may be capable of registering calling device **110** or called device **120** with a network (e.g., an IP multimedia subsystem (IMS) network). In some implementations, network registration architecture **130** may include one or more IMS network devices (not shown in FIG. **1**), such as one or more call session control function (CSCF) devices (e.g., a proxy-CSCF (P-CSCF) device, an interrogating-CSCF (I-CSCF) device, a serving-CSCR (S-CSCF) device, etc.), a home subscriber server (HSS), and/or one or more other types of IMS devices.

Similarly, application authentication architecture **140** may include one or more of a variety of computing devices. For example, application authentication architecture **140** may include a desktop computer, a server, a cluster of servers, or one or more other types of computing or communication devices. In some implementations, application authentication architecture **140** may provide one or more of a variety of authentication and/or authorization services to enable calling device **110** and called device **120** to communicate with one another via a particular network service and/or a particular communication application.

In certain implementations, application authentication architecture **140** may include a generic bootstrap architecture (GBA). Additionally, or alternatively, application authentication architecture **140** may include one or more bootstrapping server functions (BSFs), one or more network application functions (NAFs), or one or more additional or alternative functions or devices for providing authentication and authorization services. For instance, in some implementations, application authentication architecture **140** may communicate or otherwise cooperate with the devices of network registration architecture **130** (e.g., a HSS) in order to provide authentication and authorization services.

As depicted, calling device **110** or called device **120** may receive one or more security parameters from network registration architecture **130**. In some implementations, the security parameters from network registration architecture **130** may be received during, or in response to, calling device **110** or called device **120** registering with a network via network registration architecture **130**. Additionally, or alternatively, calling device **110** or called device **120** may receive one or more security parameters from application authentication architecture **140**. In some implementations, the security parameters from application authentication architecture **140** may be received in response to application authentication architecture **140** (e.g., a BSF) verifying that calling device **110** or called device **120** is authorized to access a particular network communication service or in response to application authentication architecture **140** (e.g., a NAF) verifying that calling device **110** or called device **120** is authorized to use a particular communication application.

Calling device **110** may communicate one or more of the security parameters received from network registration architecture **130** and application authentication architecture **140** to called device **120**. Similarly, called device **120** may communicate one or more of the security parameters received from network registration architecture **130** and application authentication architecture **140** to calling device **110**. In some implementations, this may ensure that calling device **110** and called device **120** apply the same security parameters to the key generation functions in order to generate security keys that complement one another. Additionally, or alternatively, calling device **110** or called device **120** may use security keys to encrypt and decrypt a communication session (e.g., a VoIP call session).

FIG. **2** is a diagram of an example environment **200** in which systems and/or methods, described herein, may be implemented. As depicted, environment **200** may include calling device **110**, called device **120**, network registration architecture **130**, application authentication architecture **140**, and network **210**. While FIG. **2** shows a particular number and arrangement of networks and devices, in alternative implementations, environment **200** may include additional networks or devices, fewer networks or devices, different networks or devices, or differently arranged networks or devices than those depicted in FIG. **2**.

Calling device **110**, called device **120**, network registration architecture **130**, and application authentication architecture **140** are each described above with reference to FIG. **1**. Network **210** may include any type of network or combination of networks. For example, network **210** may include a local area network (LAN) (e.g., an Ethernet network), a wireless LAN (WLAN) (e.g., an IEEE 802.11x network), a wide area network (WAN) (e.g., the Internet), or a wireless WAN (WWAN) (e.g., a Long-Term Evolution (LTE) network, a High-Speed Packet Access (HSPA) network, an Evolved High Rate Packet Data (eHRPD) network, etc). Network **210** may also, or alternatively, include an IMS network, a fiber optic (e.g., a fiber optic service (FiOS)) network, a VoIP network, a metropolitan area network (MAN), an ad hoc network, or a telephone network (e.g., a Public Switched Telephone Network (PSTN)).

For example, in some implementations, network **210** may include one or more LTE access networks connected to an IMS network. In such implementations, calling device **110** or called device **120** may include one or more LTE-enabled user devices (e.g., a smart phone, a tablet computer, a laptop computer, etc.). Additionally, or alternatively, network registration architecture **130** may include a P-CSCF device, an I-CSCF device, an S-CSCF device, an HSS, and/or one or more other types of network devices. In such implementations, application authentication architecture **140** may include a GBA, a BSF, one or more NAFs, and/or one or more other types of functions, systems, or devices relating to authentication.

FIG. **3** is a diagram of example components of a device **300** according to one or more implementations described herein. Device **300** may correspond to calling device **110**, called device **120**, network registration architecture **130**, and/or application authentication architecture **140**. Each of calling device **110**, called device **120**, network registration architecture **130**, and/or application authentication architecture **140** may include one or more devices **300** or one or more of the components of device **300**. As depicted, device **300** may include bus **310**, processor **320**, memory **330**, input device **340**, output device **350**, and communication interface **360**. However, in other implementations, device **300** may include fewer components, additional components, different components, or differently arranged components than those illustrated in FIG. **3**.

Bus **310** may include one or more component subsystems or communication paths that enable the components of device **300** to communicate. Processor **320** may include one or more processors, microprocessors, data processors, co-processors, network processors, application-specific integrated circuits (ASICs), controllers, programmable logic devices (PLDs), chipsets, field-programmable gate arrays (FPGAs), or other types of components that may interpret or execute instructions or data. Processor **320** may control the overall operation, or a portion thereof, of device **300**, based on, for example, an operating system and/or various applications. Processor **320** may access instructions from memory **330**, from other components of device **300**, or from a source external to device **300** (e.g., a network or another device).

Memory **330** may include memory and/or secondary storage. For example, memory **330** may include random access memory (RAM), dynamic RAM (DRAM), read-only memory (ROM), programmable ROM (PROM), flash memory, or some other type of memory. Memory **330** may include a hard disk (e.g., a magnetic disk, an optical disk, a magneto-optic disk, a solid state disk, etc.) or some other type of computer-readable medium, along with a corresponding drive. A computer-readable medium may be defined as a non-transitory memory device. A memory device may include space within a single physical memory device or spread across multiple physical memory devices.

Input device **340** may include one or more components that permit a user to input information into device **300**. For example, input device **340** may include a keypad, a button, a switch, a knob, fingerprint recognition logic, retinal scan logic, a web cam, voice recognition logic, a touchpad, an input port, a microphone, a display, or some other type of input component. Output device **350** may include one or more components that permit device **300** to output information to a user. For example, output device **350** may include a display, light-emitting diodes (LEDs), an output port, a speaker, or some other type of output component.

Communication interface **360** may include one or more components that permit device **300** to communicate with other devices or networks. For example, communication interface **360** may include some type of wireless or wired interface. Communication interface **330** may also include an antenna (or a set of antennas) that permit wireless communication, such as the transmission and reception of radio frequency (RF) signals.

As described herein, device **300** may perform certain operations in response to processor **320** executing software instructions contained in a computer-readable medium, such as memory **330**. The software instructions may be read into memory **330** from another computer-readable medium or from another device via communication interface **360**. The software instructions contained in memory **330** may cause processor **320** to perform one or more processes described herein. Alternatively, hardwired circuitry may be used in place of, or in combination with, software instructions to implement processes described herein. Thus, implementations described herein are not limited to any specific combination of hardware circuitry and software.

FIG. **4** is a diagram of example functional components **400** corresponding to one or more implementations described herein. For example, calling device **110** or called device **120** may include functional components **400**. As depicted, functional components **400** may include registration module **410**, communication application module **420**, security parameters module **430**, and key generation module **440**. Depending on the implementation, one or more of modules **410-440** may be implemented as a combination of hardware and software based on the components illustrated and described with respect to FIG. **3**. Alternatively, modules **410-440** may each be implemented as hardware based on the components illustrated and described with respect to FIG. **3**. While FIG. **4** shows a particular number and arrangement of modules, in alternative implementations, functional components **400** may include additional modules, fewer modules, different modules, or differently arranged modules than those depicted.

Registration module **410** may provide calling device **110** or called device **120** with functionality regarding network registration. For example, network registration module **410** may communicate with network registration architecture **130** to register with network **210**, which may include establishing a communication session (e.g., a SIP session) with network **210**. Additionally, or alternatively, network **210** may associate the communication session with a random number (e.g., a RAND, a RAND_ID, a session identifier, etc.) or other data structure that may be used to setup and identify the communication session. As described below, a RAND may also be used as a security parameter for generating a security key.

In some implementations, by registering with network **210**, calling device **110** or called device **120** may be granted access to one or more network services (e.g., standard calling services, Internet access, etc.). However, other network services (e.g., VoIP services, SMS services, IM services, video conferencing services, etc.) may require one or more additional authentication or authorization processes. For example, obtaining access to network services, corresponding to a particular communication, application may require application authentication architecture **140** to perform one or more application authentication procedures as described herein.

Communication application module **420** may provide calling device **110** or called device **120** with functionality regarding communication applications. For instance, communication application module **420** may include a VoIP application that enables calling device **110** or called device **120** to communicate over network **210** via VoIP. In implementations where a communication application requires authentication, communication application module **420** may communicate with application authentication architecture **140** to complete the authentication process.

Application authentication architecture **140** may communicate with network registration architecture **130** (e.g., HSS) to determine whether calling device **110** or called device **120** is authorized for a particular network service (e.g., a VoIP service, SMS service, etc.). Application authentication architecture **140** may also, or alternatively, associate an authentication or authorization process with a transaction identifier (e.g., a bootstrapping transaction identifier (B-TID)) in order to track the process. Additionally, or alternatively, a NAF identifier (e.g., a NAF_ID) may be used to derive a NAF key (e.g., an external NAF key, Ks_ext_NAF, etc.), and a NAF key may be submitted to a NAF so that calling device **110** or called device **120** may, for example, use a stored communication application to gain access to a particular network service.

Security parameters module **430** may provide calling device **110** or called device **120** with functionality regarding security parameters. For instance, security parameters module **430** may collect security parameters (e.g., a RAND_ID) received by network registration module **410** during a network registration process, or security parameters (e.g., a B-TID, Ks_ext_NAF, etc.) received by communication application module **420** during an authentication or authorization process. Security parameters module **430** may also, or alternatively, collect one or more security parameters that may be available locally. Examples of such parameters may include a telephone number or another type of identifier associated with calling device **110** (e.g., a CALLING_ID), a telephone number or another type of identifier associated with called device **120**, and/or an identifier associated with a network service or network application function (e.g., a NAF_ID).

Security parameters module **430** may communicate one or more security parameters to called device **120** and, in response, receive one or more security parameters from called device **120**. Alternatively, security parameters module **430** may receive one or more security parameters from calling device **110** and, in response, collect and communicate security parameters to the calling device **110**. In some implementations, security parameters collected by, communicated by, or otherwise corresponding to calling device **110** may be identified as calling security parameters (e.g., CALLING_RAND_ID, CALLING_B-TID, etc.). Similarly, security parameters collected by, communicated by, or otherwise corresponding to called device **120** may be identified as called security parameters (e.g., CALLED_RAND_ID, CALLED_B-TID, etc.).

Key generation module **440** may provide calling device **110** or called device **120** with functionality regarding security keys. For example, key generation module **440** may generate a security key based on one or more of the security parameters collected or otherwise obtained by security parameters module **430**. In some implementations, key generation module **440** may generate a security key by executing one or more key generation functions, which may include a key derivation function (KDF) or another type of hash function. In some implementations, a KDF may be implemented according to one or more communication standards, such as the 3rd Generation Partnership Project (3GPP). As mentioned above, a security key may be used to encrypt and decrypt data structures (e.g., IP packets) of a communication session.

FIG. **5** is a diagram of an example data flow **500** for generating a security key according to one or more implementations described herein. Example data flow **500** is presented from the perspective of calling device **110** collecting or otherwise obtaining security parameters. A similar or analogous data flow could be applicable to called device **120**.

As depicted, security parameters may be obtained by calling device **110** from different sources and at different times. For example, calling device **110** may receive a CALLING_RAND parameter or another type of security parameter from network registration architecture **130** while registering with network **210**. Additionally, or alternatively, calling device **110** may receive a CALLING_B-TID parameter, a CALLING_Ks-ext-NAF parameter, or one or more other types of security parameters while communicating with application authentication architecture **140** to, for example, obtain authorization to access a particular network service or use a particular communication application.

Calling device **110** may also, or alternatively, receive a CALLED_RAND parameter, a CALLED_B-TID parameter, a CALLED_Ks-ext-NAF parameter, or one or more other types of security parameters in response to sending one or more calling security parameters (e.g., a CALLING_RAND parameter, a CALLING_B-TID parameter, a CALLING_Ks-ext-NAF parameter, etc.) to called device **120**. In some implementations, one or more security parameters may be locally available to calling device **110** (e.g., a NAF_ID parameter, a CALLING_ID parameter, a CALLED_ID parameter, etc.).

As illustrated, one or more of the foregoing parameters may be inserted or otherwise applied to a key generation function (e.g., a KDF) to generate a security key. The security key may be used to encrypt or decrypt messages or other information sent to and from called device **120**. As mentioned above, data flow **500** provides an example for generating a security key from the perspective of calling device **110**. As described below with reference to FIGS. **7-8**C, an analogous data flow could be applied to called device **120**.

FIG. **6** is a diagram of an example process **600** for generating a security key according to one or more implementations described herein. Process **600** may be performed by, or otherwise correspond to, calling device **110**. In one or more implementations, process **600** may be performed by one or more components of calling device **110**. In other implementations, one or more blocks of process **600** may be performed by one or more other components/devices, or a group of components/devices, including or excluding calling device **110**.

Process **600** may include registering with network **210** (block **610**). For example, calling device **110** may communicate with network registration architecture **130** to register with network **210**. In some implementations, registering with network **210** may enable calling device **110** to, for example, obtain access to some network services, such as standard calling services, Internet services, television services, or one or more other types of network services. As mentioned above, however, some network services may require calling device **110**, or one or more communication applications of calling device **110**, to be authenticated by application authentication architecture **140**.

Calling security parameters may be obtained (block **620**). For instance, calling device **110** may obtain calling security parameters from various sources or at various times. In some implementations, calling device **110** may obtain a CALLING_RAND parameter from network registration architecture **130** in response to registering with network **210**. Calling device **110** may also, or alternatively, obtain a CALLING_B-TID parameter or a CALLING_Ks-ext-NAF parameter from interacting with application authentication architecture **140**. Calling device **110** may also obtain security parameters that are locally available, such as a NAF_ID parameter, a CALLING_ID parameter, or a CALLED_ID parameter.

Calling security parameters may be communicated (block **630**). For example, calling device **110** may send parameters to called device **120**. In certain implementations, calling device **110** may communicate one or more calling security parameters using a session initiation message, such as a SIP INVITE message. In such implementations, security parameters may be included in the SIP INVITE message by using session description protocol (SDP).

Called security parameters may be received (block **640**). For example, calling device **110** may receive called security parameters from called device **120**. As discussed above with reference to FIG. **5**, called security parameters may include a CALLED_RAND parameter, a CALLED_B-TID parameter, a CALLED_Ks-ext-NAF parameter, and/or one or more other types of security parameters, such as a CALLED_ID parameter, a CALLING_ID parameter, or a NAT_ID parameter. In some implementations, one or more of the security parameters sent by called device **120** may already be locally available to calling device **110**. However, calling device **120** may use such security parameters (e.g., redundant security parameters) to verify that calling device **110** and called device **120** will be applying the same parameters to the key generation function.

A security key may be generated (block **650**). For instance, calling device **110** may generate a security key using one or more key generation functions, as described above. Additionally, or alternatively, the security key may be based on the calling security parameters and/or the called security parameters collected or obtained by calling device **110**.

While FIG. **6** shows a flowchart diagram of an example process **600** for generating a security key, in other implementations, a process for generating a security key may include fewer operations, different operations, differently arranged operations, or additional operations than depicted in FIG. **6**.

FIG. **7** is a diagram of an example process **700** for generating a security key according to one or more implementations described herein. As depicted, process **700** may include one or more operations that are similar or analogous to the process of FIG. **6**. However, while the process of FIG. **6** may be performed by calling device **110**, process **700** may be performed by called device **120**. For instance, in one or more implementations, process **700** may be performed by one or more components of called device **120**. In other implementations, one or more blocks of process **700** may be performed by one or more other components/devices, or a group of components/devices, including or excluding called device **120**.

Process **700** may include registering with network **210** (block **710**). For example, called device **120** may register with network **210**. In some implementations, called device **120** may register with network **210** by communicating with network registration architecture **130**. In certain implementations, registering with network **210** may enable called device **120** to, for example, obtain access to one or more network services, such as standard calling services, Internet services, television services, or one or more other types of network services. However, some network services may require called device **120**, or a communication application of called device **120**, to be authenticated by application authentication architecture **140**.

Calling security parameters may be received (block **720**). For instance, called device **120** may receive one or more calling security parameters from calling device **110**. The calling security parameters may be included in a session initiation message (e.g., a SIP INVITE message). In certain implementations, the calling security parameters may include a NAF_ID parameter, a CALLING_ID parameter, a CALLED_ID parameter, a CALLING_RAND parameter, a CALLING_B-TID parameter, a CALLING_Ks-ext-NAF parameter, or one or more other types of security parameters. In some implementations, one or more of the security parameters sent by calling device **110** may already be locally available to called device **120**. However, called device **120** may use the security parameters (e.g., the redundant security parameters) to verify that calling device **110** and called device **120** are applying the same parameters to the key generation function.

Called security parameters may be obtained (block **730**). For example, called device **120** may obtain called security parameters from one or more sources or at one or more times. For example, called device **120** may obtain a CALLED_RAND parameter from network registration architecture **130** in response to registering with network **210**. Called device **120** may also, or alternatively, obtain a CALLED_B-TID parameter, a CALLED_Ks-ext-NAF parameter, or another type of security parameter as a result of interacting with application authentication architecture **140**. Called device **120** may also, or alternatively, obtain security parameters that are available locally, such as a NAF_ID parameter, a CALLING_ID parameter, or a CALLED_ID parameter.

Called security parameters may be communicated (block **740**). For instance, called device **120** may send, or otherwise communicate, called security parameters to calling device **110**. In some implementations, called device **120** may communicate called security parameters in response to, for example, receiving a communication session invitation (e.g., a SIP INVITE message) with calling security parameters from calling device **110**. In such implementations, calling device **110** may respond by sending the calling security parameters in a SIP response message, such as a SIP RINGING message that may be modified using SDP to include the called security parameters.

A security key may be generated (block **750**). For instance, called device **120** may generate a security key. In some implementations, called device **120** may generate a security key using a key generation function (e.g., a KDF), as described above. Additionally, or alternatively, the security key may be based on one or more security parameters. For instance, in some implementations, called device **120** may generate a security key by executing one or more KDFs based on one or more of the calling security parameters and/or one or more of the called security parameters.

While FIG. **7** shows a flowchart diagram of an example process **700** for generating a security key, in other implementations, a process for generating a security key may include fewer operations, different operations, differently arranged operations, or additional operations than depicted in FIG. **7**.

FIGS. **8**A-**8**C are diagrams of an example call session **800** (referenced individually by **800**A, **800**B, and **800**C, respectively) according to one or more implementations described herein. As depicted, call session **800** may involve calling device **110**, called device **120**, gateway **810-1**, gateway **810-2**, P-CSCF device **820**, I-CSCF device **830**, S-CSCF device **840**, HSS **850**, telephony application server (TAS) **860-1**, TAS **860-2**, policy charging and rules function (PCRF) device **870-1**, PCRF device **870-2**, and call delivery application server (CDAS) **880**. While FIGS. **8**A-**8**C represent a particular number and arrangement of devices, operations, and data structures, in alternative implementations, a call session may include additional devices, operations, and data structures, fewer devices, operations, and data structures, different devices, operations, and data structures, or differently arranged devices, operations, and data structures than those depicted in FIGS. **8**A-**8**C.

Referring to FIG. **8**A, call session **800**A may begin with calling device **110** triggering a GBA function (e.g., a BSF) to obtain GBA parameters (e.g., a CALLING_B-TID parameter, a CALLING_Ks-ext_NAF parameter, or other types of security parameters). In some implementations, this may include calling device **110** communicating with application authentication architecture **140** and receiving one or more security parameters, such as a CALLING_B-TID parameter, a CALLING_Ks-ext-NAF parameter, or another type of security parameter. Additionally, or alternatively, calling device **110** may register with network **210** before triggering the GBA (see, for example, FIG. **6**, blocks **610** and **620**).

Calling device **110** may send a session initiation message that includes the GBA parameters (event **1**). The session initiation message may include a SIP INVITE 100rel, timer message that is modified with SDP to include the GBA parameters. As depicted, the session invitation message may be routed to various devices, including P-CSCF device **820**, S-CSCF device **840**, TAS **860-1** (which may perform number completion from 7 digits to E.164 format), TAS **860-2**, and CDAS **880** (events **2-9**). The session initiation message may arrive at called device **120** via gateway **810-2** (event **10**).

Similar to calling device **110**, called device **120** may trigger a GBA process to obtain GBA parameters, such as a CALLED_B-TID, a CALLED_Ks-ext-NAF, or one or more other types of security parameters (see, for example, FIG. **7**, block **730**). As depicted, called device **120** may communicate a SIP RINGING message (180) that has been modified with SDP to include the GBA parameters obtained by called device **120** (event **11**). The SIP RINGING message may be passed to several network devices, including P-CSCF device **820**, S-CSCF device **840**, CDAS **880**, TAS **860-2**, and TAS **860-1** (events **12-19**). The SIP RINGING message may arrive at calling device **110** via gateway **810-1** (event **20**), which may result in calling device **110** generating a local ringing tone.

At this point, calling device **110** and calling device **120** may each derive or otherwise calculate a security key using, for example, a KDF. As depicted, calling device **110** may produce a SIP provisional acknowledgement (PRACK) message in response to the SIP RINGING message from called device **120** (event **21**). The SIP PRACK message may be modified to include GBA parameters. Additionally, or alternatively, the SIP PRACK message may be communicated to various network devices including P-CSCF device **820**, S-CSCF device **840**, TAS **860-1**, TAS **860-2**, and CDAS **880** (events **22-29**). The SIP PRACK message may arrive at called device **120** via gateway **810-2** (event **30**).

Called device **120** may communicate a SIP OK message (200) in response to the SIP PRACK message of calling device **110**. Similar to several of the SIP messages discussed above, the SIP OK message may be communicated to several network devices. For example, the SIP OK message may be sent to P-CSCF device **820**, S-CSCF device **840**, CDAS **880**, TAS **860-2**, and TAS **860-1** (events **31-39**).

Referring to FIG. **8**B, the SIP OK message from called device **120** may arrive at calling device **110** via gateway **810-1** (event **40**). Called device **120** may also, or alternatively, communicate a SIP OK (200) message corresponding to the SIP

INVITE message of calling device **110**, which may be received by P-CSCF **820** (event **41**).

As depicted, an authentication authorization request (AAR) message and an authentication authorization answer (AAA) message may be exchanged between P-CSCF **820** and PCRF **870-2** via an Rx interface. Additionally, a re-authentication request (RAR) message and re-authentication answer (RAA) message may be exchanged between PCRF device **870-2** and gateway **810-2** via a Gx interface.

The SIP OK message corresponding to the SIP INVITE message may be sent to S-CSCF **840**, CDAS **880**, TAS **860-2**, TAS **860-1**, and again to S-CSCF device **840** and P-CSCF device **820** (events **42-49**). Similar to the Rx and Gx interface exchanges mentioned above, an authentication authorization request (AAR) message and an authentication authorization answer (AAA) message may be exchanged between P-CSCF **820** and PCRF **870-1** via an Rx interface. Additionally, a re-authentication request (RAR) message and re-authentication answer (RAA) message may be exchanged between PCRF device **870-1** and gateway **810-1** via a Gx interface.

The SIP OK message corresponding to the SIP INVITE message may be received by calling device **110** (event **50**). At this stage, calling device **110** and called device **120** may begin encrypting and decrypting a voice payload of the call session using the previously generated security keys. As depicted, a SIP acknowledgement (ACK) message may be sent from calling device **110** to called device **120** via a sequence of transmissions (events **51-60**) that is similar to the communications described above.

Referring to FIG. **8**C, a SIP BYE message may also be sent from calling device **110** to called device **120** using a similar sequence of transmission (events **61-70**). As the SIP BYE message is being transmitted to called device **120**, session termination request (STR) messages and session termination answer (STA) messages may be exchanged between P-CSCR device **820** and PCRF device **870-1** and between P-CSCR device **820** and PCRF device **870-1**, via Rx interfaces. Similarly, RAR message and RAA messages may be exchanged between PCRF **870-1** and GW **810-1** and between PCRF **870-2** and GW **810-2**, via Gx interfaces. In response to the SIP BYE message, called device **120** may communicate a SIP OK (200) message, which may use a sequence of transmissions similar to those discussed above (events **71-81**).

In one or more implementations, described herein, devices may be used to generate security keys locally. For instance, calling device **110** may receive calling security parameters by registering with network **210** and interacting with application authentication architecture to demonstrate that calling device **110** is authorized to access a particular network service (e.g., a VoIP service) and/or use a particular communication application (e.g., a VoIP application). Calling device **110** may communicate the calling security parameters to called device **110** and, in response, receive called security parameters from called device **110**. Calling device **110** and called device **120** may each execute a key generation function based on the calling security parameters and the called security parameters to locally generate security keys that may be used to encrypt and/or decrypt information passed between calling device **110** and called device **120**.

It will be apparent that example aspects, as described above, may be implemented in many different forms of software, firmware, and hardware in the implementations illustrated in the figures. The actual software code or specialized control hardware used to implement these aspects should not be construed as limiting. Thus, the operation and behavior of the aspects were described without reference to the specific software code—it being understood that software and control hardware could be designed to implement the aspects based on the description herein.

Further, certain implementations may involve a component that performs one or more functions. These components may include hardware, such as an ASIC or a FPGA, or a combination of hardware and software.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit disclosure of the possible implementations. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one other claim, the disclosure of the implementations includes each dependent claim in combination with every other claim in the claim set.

No element, act, or instruction used in the present application should be construed as critical or essential to the implementations unless explicitly described as such. Also, as used herein, the article "a" is intended to include one or more items. Where only one item is intended, the term "one" or similar language is used. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. A method, comprising:

obtaining, by a calling device, a first calling security parameter by registering with a network;

obtaining, by the calling device, a second calling security parameter in response to causing an application authentication architecture of the network to verify that the calling device is authorized to access a network service corresponding to a communication application stored by the calling device;

communicating the first calling security parameter and the second calling security parameter to a called device;

receiving a first called security parameter and a second called security parameter from the called device in response to communicating the first calling security parameter and the second calling security parameter;

generating a security key based on the first calling security parameter, the second calling security parameter, the first called security parameter, and the second called security parameter; and

using the security key to encrypt or decrypt communication between the calling device and the called device.

2. The method of claim **1**, further comprising:

establishing a communication session with the called device; and

using the security key to encrypt information communicated to the called device and decrypt information received from the called device during the communication session.

3. The method of claim **1**, further comprising:

obtaining a third calling security parameter comprising a data structure used to demonstrate to the application authentication architecture that the calling device is authorized to use the communication application to establish a communication session within the network; and

communicating the third calling security parameter to the called device with the first calling security parameter and the second calling security parameter.

4. The method of claim **3**, further comprising:

receiving a third called security parameter, from the called device, with the first called security parameter and the second called security parameter, where the third called security parameter comprises a data structure used to demonstrate to the application authentication architecture that the called device is authorized to use a communication application that corresponds to the communication application of the calling device.

5. The method of claim **1**, where the first calling security parameter comprises a data structure identifying a network session associated with the calling device upon registering with the network.

6. The method of claim **1**, where:

the first called security parameter comprises a data structure identifying a network session associated with the called device upon registering with the network, and

the second called security parameter comprises a security parameter type and security parameter format consistent with the second calling security parameter.

7. The method of claim **1**, where communicating the first calling security parameter and the second calling security parameter comprises sending a session communication invitation, comprising the first and second calling security parameters, to the called device.

8. The method of claim **1**, where generating the security key comprises executing a key generation function, where:

an input of the key generation function comprises the first calling security parameter, the second calling security parameter, the first called security parameter, and the second called security parameter, and

an output of the key generation function is the security key.

9. The method of claim **8**, where the key generation function comprises a key derivation function (KDF) that is identical to a KDF used by the called device to generate security keys.

10. The method of claim **1**, where:

the network comprises an Internet Protocol (IP) multimedia subsystem (IMS) network,

the application authentication architecture comprises a generic bootstrap architecture (GBA) of the IMS network, and

the second calling security parameter comprises a bootstrap transaction identifier (B-TID).

11. A first device, comprising:

a memory to:

store a communication application to enable the first device to establish a first communication session with a second device using a selected network service, and

store a first key generation function to enable the first device to generate a security key; and

a processor, connected to the memory, to:

register the first device with a network, where registering with the network comprises receiving a first network session identifier from the network,

communicate with an application authentication architecture of the network to demonstrate that the first device is authorized to use the selected network service, where communicating with the application authentication architecture comprises receiving a first transaction identifier from the application authentication architecture,

communicate the first network session identifier and the first transaction identifier to the second device,

receive a second network session identifier and a second transaction identifier from the second device, and

execute the first key generation function to generate a security key based on the first network session identifier, the first transaction identifier, the second network session identifier, and the second transaction identifier.

12. The first device of claim **11**, where the first device obtains access to at least one network service, other than the selected network service, upon registering with the network.

13. The first device of claim **11**, where the processor is to:

establish a communication session, with the second device, using the selected network service, and

use the security key to encrypt information sent to the second device via the selected network service and decrypt information received from the second device via the network service.

14. The first device of claim **11**, where the processor is to:

obtain a first data structure used to demonstrate to the application authentication architecture of the network that the first device is authorized to use the communication application to establish a communication session within the network, and

communicate the first data structure, to the second device, the first network session identifier and the first transaction identifier.

15. The first device of claim **14**, where the first transaction identifier comprises a data structure that associates the first device with a first authentication process, performed by the application authentication architecture, to verify that the first device is authorized to use the communication application.

16. The first device of claim **14**, where the processor is to:

receive a second data structure, from the second device, with the second network session identifier and the second transaction identifier, where the second data structure comprises information used to demonstrate to the application authentication architecture that the second device is authorized to use a communication application that corresponds to the communication application stored by the first device.

17. The first device of claim **11**, where the second transaction identifier comprises a data structure that associates the second device with a second authentication process, performed by the application authentication architecture, to verify that the second device is authorized to use a communication application that corresponds to the communication application stored by the first device.

18. The first device of claim **11**, where, to communicate the first network session identifier and the first transaction identifier to the second device, the processor is to:

generate a communication session invitation directed to the second device,

include the first network session identifier and the first transaction identifier in the communication session invitation, and

send the communication session invitation to the second device.

19. The first device of claim **11**, where:

the network comprises an Internet Protocol (IP) multimedia subsystem (IMS) network, and

the application authentication architecture comprises a generic bootstrap architecture (GBA) of the IMS network.

20. A non-transitory computer-readable medium storing a program for causing a first device to perform a method, the method comprising:

obtaining a first security parameter by communicating with a generic bootstrapping architecture (GBA) to demonstrate that the first device is authorized to use a selected network communication service for establishing a communication session within a network, where the first security parameter is generated by the GBA to associate the first device with a first GBA authentication process;

obtaining a second security parameter from a second device in response to communicating the first security parameter to the second device, where the second security parameter is obtained by the second device by communicating with the GBA to demonstrate that the second device is authorized to use the selected network communication service, where the second security parameter is generated by the GBA to associate the second device with a second GBA authentication process;

generating a security key based on the first security parameter and the second security parameter; and

using the security key to establish an encrypted communication session, using the selected network communication service, with the second device.

21. The computer-readable medium of claim **20**, where the method further comprises:

obtaining a third security parameter by registering with the network, where:

registering with the network enables the first device to communicate with the GBA, and

the third security parameter is generated by a network registration architecture of the network to identify a network session associated with the first device; and

generating the security key based on the first security parameter, the second security parameter, and the third security parameter.

22. The computer-readable medium of claim **20**, where:

the network comprises an Internet Protocol (IP) multimedia subsystem (IMS) network, and

the network communication service corresponds to a voice over IP (VoIP) communication service.

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